

Robotics for Human Exploration

The human return to the Moon offers many new opportunities for scientific exploration. But, when manned missions land on the lunar surface near 2020, humans will initially be present less than one month per year. During the rest of time, however, robots will be available to perform work, remotely controlled from the Earth. A central challenge, therefore, is to understand how human and robot activities can be coordinated to maximize mission success.

Robots can do a variety of work to increase the productivity of human explorers. Robots can perform tasks (systematic survey, inspection, etc.) that are tedious, highly-repetitive or long-duration. Robots can perform tasks, such as advance scouting, that help prepare for future crew activity. Robots can also perform "follow-up" work, completing tasks designated or started by humans.

Since 2004, the Intelligent Robotics Group has been working to make human-robot interaction efficient and effective for space exploration. A central focus of our research has been to develop and field test robots that benefit human exploration. Our approach is inspired by lessons learned from the Mars Exploration Rovers (MER), as well as human spaceflight programs, including Apollo, the Space Shuttle, and the International Space Station.



Arm Lab



IRG's ArmLab is developing tools and techniques for mobile manipulation. Facilities include two Amtec Light Weight Arms and Barrett 3-finger grippers. Research currently focuses on using non-prehensile manipulation methods (pushing, tapping, rolling) for lunar surface operations. These methods require the robot to have some understanding of the physics of interacting with a part, particularly friction and contact.

Planetary Rovers



IRG develops mobile robots to demonstrate and validate technologies required by future exploration missions. K9 is a planetary rover used for studying autonomous instrument deployment and remote science. K10 is a field-work rover designed for site support tasks such as survey and inspection. K11 is a power-efficient rover designed for polar environments.

Rover Testbeds



IRG operates two facilities for testing and evaluating planetary rovers. The Marscape is a 40m x 80m Mars surface analog site, which includes terrain representative of the geological features of greatest scientific interest. The Moonscape is a 250 sq. meter indoor test area with high-precision optical tracking that provides local area positioning of rovers and human subjects.

The NASA Ames Intelligent Robotics Group (IRG) is dedicated to enabling humans and robots to explore and learn about extreme environments, remote locations, and uncharted worlds. IRG conducts applied research in a wide range of areas with an emphasis on robotics systems science and field testing. IRG's expertise includes applied computer vision, human-robot interaction, interactive 3D visualization, and robot software architecture.

We firmly believe that collaboration is an essential part of modern research, especially for improving quality and speeding technology transfer. Thus, we actively encourage joint projects with academia, government, and industry. If you have an application that can benefit from our technology, or if you are interested in starting a collaboration, please contact us today.

For more information about the Intelligent Robotics Group:

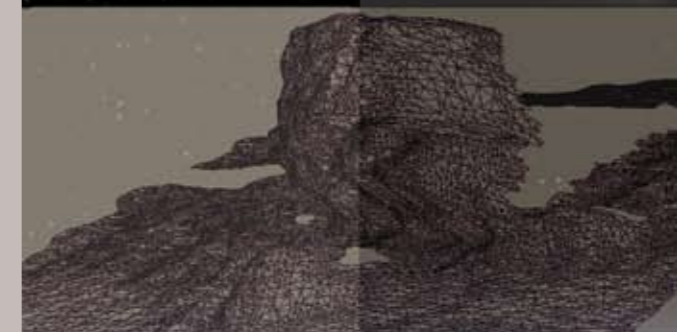
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Intelligent Robotics Group



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Intelligent Robotics

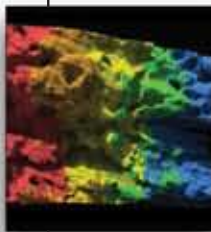
Perception, Interaction, and Architecture for Planetary Exploration

GigaPan



GigaPan makes creating billion-pixel panoramas easy to do. The low-cost GigaPan robotic camera mount captures hundreds of images, which are combined into interactive panoramas with the GigaPan stitcher. These panoramas have a myriad of uses including discovery, education, entertainment, and science. GigaPan is part of the Global Connection Project, a partnership between NASA, Carnegie Mellon University, and Google. Visit gigapan.org.

NASA Vision Workbench



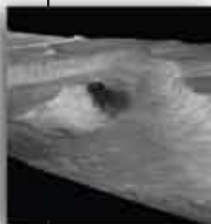
The NASA Vision Workbench (VW) is an open-source C++ framework for efficient computer vision. Vision Workbench has been used to create gigapixel panoramas, 3D terrain models from satellite images, and high-dynamic range images for visual inspection. Vision Workbench supports rapid development on multiple platforms. Visit ti.arc.nasa.gov/visionworkbench.

Pipeline Threat Detection



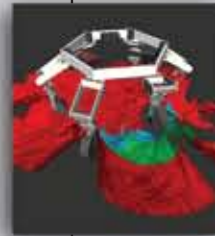
The Pipeline Threat Detection project is developing algorithms to automatically detect the presence of heavy digging equipment near oil and gas pipelines. Data from aerial cameras, lidar, and thermal sensors are combined and analyzed using computer vision and machine learning techniques. Improving threat detection will help reduce the risk and cost of pipeline damage.

Terrain Reconstruction



Digital terrain models have long been essential for science analysis, mission planning and mission operations. We have developed the Ames Stereo Pipeline and Terrain Pipeline to generate high-quality topographic models automatically from a mixture of 3D range data (stereo images, lidar scans, etc.) and stereo imagery (satellites and rovers).

ATHLETE Footfall Planning



We are developing a planning system to enable JPL's ATHLETE robot to walk on natural terrain. Our system processes images from robot cameras into 3D terrain models, which are automatically analyzed for stability, reachability, and traversability. A 3D user interface and motion planner enables remote operators to plan and visualize robot steps.

GeoCam



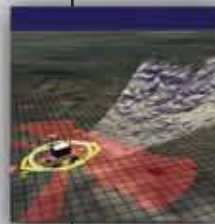
The GeoCam project helps people better understand and respond to disasters. GeoCam consists of a GPS-enabled camera and a "live" workflow that publishes photos (via Google Earth) in seconds. Many cameras can be used, from aerial imagers to camera cellphones. Disaster responders have used GeoCam for large-scale urban search and rescue exercises and on-site at a major wildfire.

Science Operations for Robots



To understand how best to integrate ground-based "backroom" teams into lunar surface operations, we are developing a new ground control based on experience from Apollo, Shuttle, Space Station, and the Mars Exploration Rovers. We are testing the ground control with planetary scientists and the JSC Mission Operations Directorate.

Viz



Viz is a data visualization tool that provides scientists, robot operators, and mission planners with powerful, interactive 3D displays of remote environments. Viz has been used to operate multiple robots, to analyze science data, and to display high-resolution terrain. Viz was originally developed for Mars Polar Lander (2001), and has since been used for the Mars Exploration Rover (2003) and the Phoenix lander (2008).

Lunar Mapping and Modeling



NASA's goal of returning to the Moon has led to renewed interest in lunar data sets and lunar science. The Lunar Mapping and Modeling Project is producing cartographic products for NASA mission planners and planetary scientists. Our work involves processing on an unprecedented scale, using terabytes of data acquired by the Lunar Reconnaissance Orbiter as well as newly processed Apollo mapping camera images.

Planetary Content



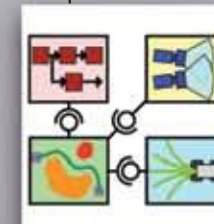
The Planetary Content project makes NASA's vast stores of planetary data more accessible and useful through Web-enabled tools. In collaboration with Google, Planetary Content has produced Google Mars 3D, Google Moon, and the NASA Gallery in Google Earth. Planetary Content develops everything from educational content for the general public to high-performance interfaces for scientists.

Human-Robotic Systems



We are developing and field testing robots to understand how they can be used between manned exploration missions to improve crew productivity and science return. When humans return to the Moon, crews will initially be on the surface less than 10% of the time. Robots can perform work even when humans are not present, including reconnaissance, survey, and inspection.

Rover Software Systems



IRG's rover software system is a service-oriented architecture that encapsulates robot functions (locomotion, navigation, localization, instrument control, etc.) as self-contained computing services. With this approach, robotic applications can be built as a collection of on-demand services. This enables complex, extensible and scalable development to be performed in a highly efficient manner.